July 27, 1965 A. W. KAMMERER 3,196,961

FLUID PRESSURE EXPANSIBLE ROTARY DRILL BITS

Filed April 22, 1963 2 Sheets-Sheet 1

FIG. 1.

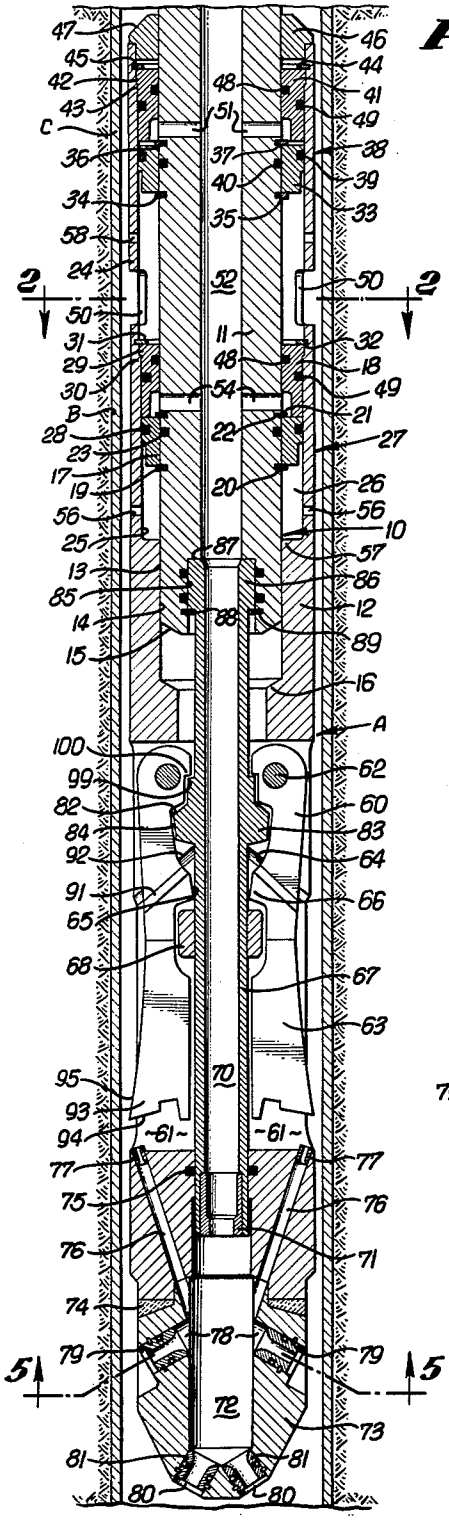


FIG. 2.

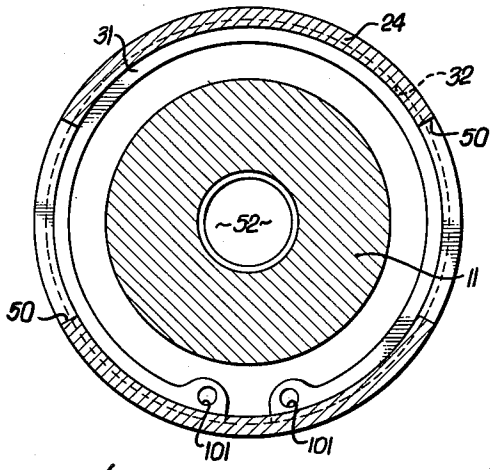
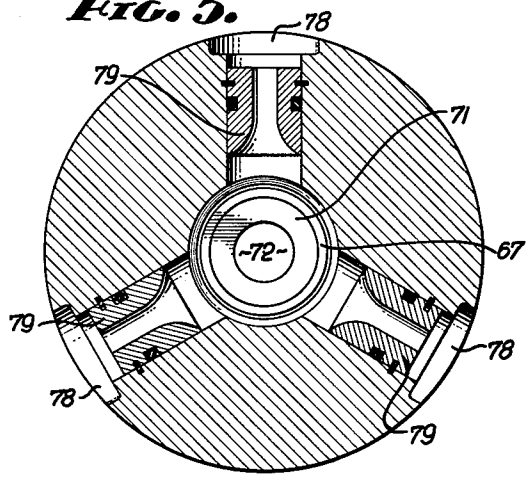


FIG. 5.



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FIG. 3.

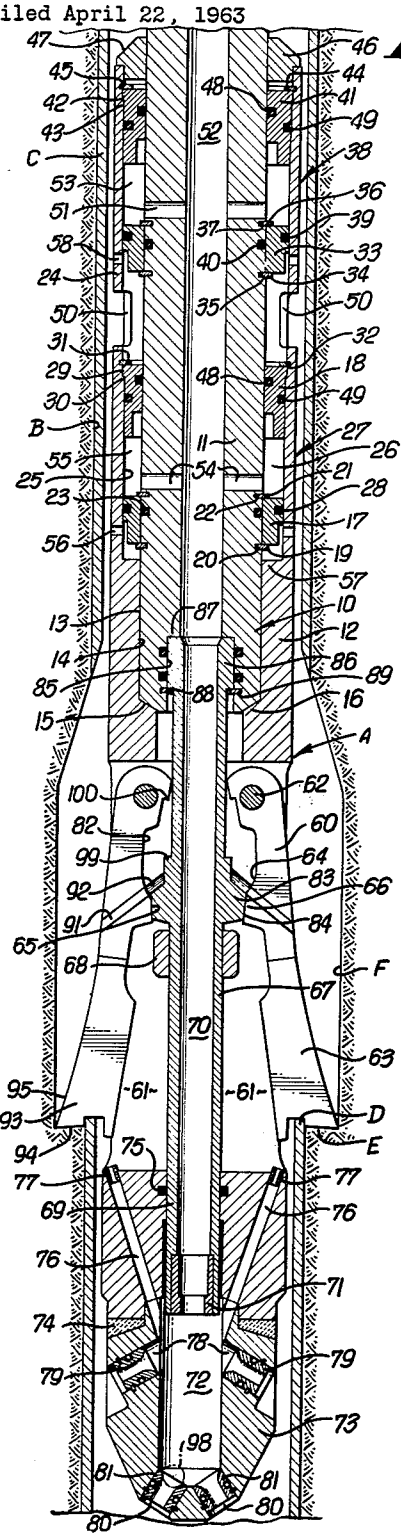
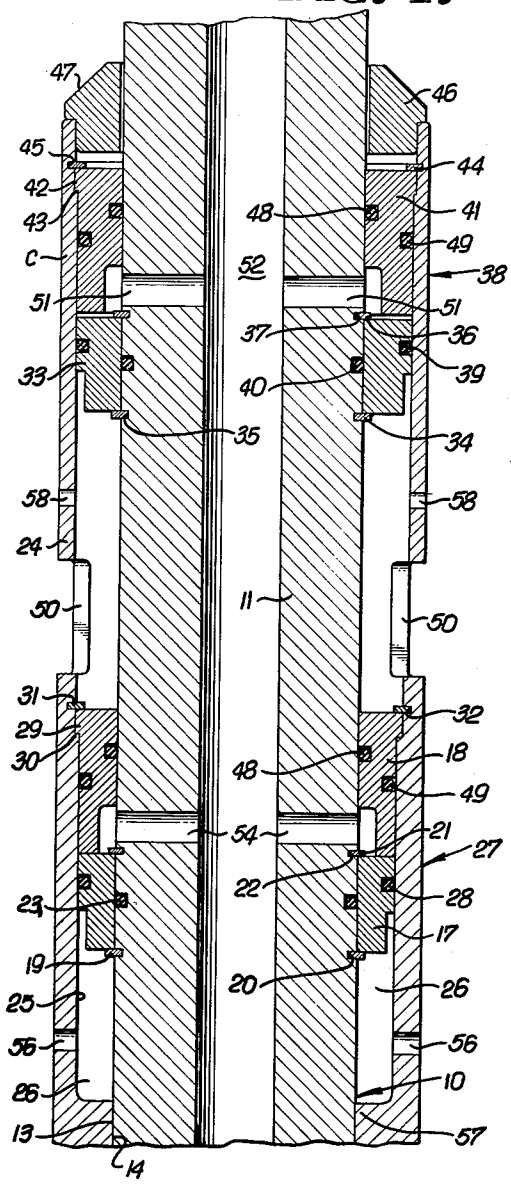


FIG. 4.



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3,196,961

FLUID PRESSURE EXPANSIBLE ROTARY DRILL BITS

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Filed Apr. 22, 1963, Ser. No. 274,515
9 Claims. (Cl. 175—267)

The present invention relates to rotary drill bits, and more particularly to drill bits of the expansible type to be used in well bores, in which the cutters are expanded outwardly by fluid pressure.

The cutters of a rotary drill bit of the expansible type have been expanded outwardly by applying fluid pressure to a fluid pressure actuatable portion of the bit. Such portion has heretofore possessed a comparatively limited area on which the fluid pressure could act, because of size limitations governed by the diameter of the well bore or casing in which the bit was used. Because of the limited area of action of the fluid pressure, the total force available for cutter expansion has been relatively low, increasing the time required for achieving full cutter expansion in the well bore against the resistance of the well bore wall, or wall of the casing string, or the like, on which the cutters are operating. In enlarging hole diameters in very hard formations, or in cutting through the wall of well casing, the total fluid force available for fully expanding the cutters has been, in some cases, inadequate.

Accordingly, it is an object of the present invention to provide a rotary drill bit having cutters expandible outwardly by fluid pressure, in which the fluid pressure actuatable portion of the bit has a greatly increased area, enabling a much greater fluid cutter expansion force for the same unit fluid pressure to be developed in the bit.

Another object of the invention is to provide a rotary drill bit in which the area over which fluid pressure can act in effecting expansion of the bit cutters is greatly increased without increasing the diameter of the bit with its cutters in retracted position. In a more limited sense, the invention contemplates a tandem cylinder and piston arrangement in which the fluid pressure is effective for expanding the cutters, thereby multiplying the force producing cutter expansion over preexisting drill bits.

A further object of the invention is to provide a rotary drill bit having cutters expandible by fluid pressure, in which a tandem cylinder and piston arrangement is provided to which the fluid pressure is directed, and in which the tandem arrangement can be assembled and disassembled in a comparatively facile manner.

An additional object of the invention is to provide a rotary drill bit having cutters adapted for outward expansion by fluid pressure acting within a tandem cylinder and piston arrangement, the drill bit being comparatively economical to manufacture and being of strong and sturdy construction.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through a drill bit disposed within a well casing in a well bore, with the drill bit parts in retracted position;

FIG. 2 is an enlarged cross-section taken along the line 2—2 on FIG. 1;

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FIG. 3 is a view similar to FIG. 1 disclosing the drill bit cutters in expanded position;

FIG. 4 is an enlarged longitudinal section of the hydraulic actuating portion of the bit disclosed in FIG. 1;

FIG. 5 is an enlarged cross-section taken along the line 5—5 on FIG. 1.

The drill bit A illustrated in the drawings is of the rotary expansible type and may be used for enlarging the diameter of a well bore B, cutting through and milling away a portion of a string of well casing C located within the well bore, or for performing a combination of casing milling and hole enlarging operations. The drill bit is lowered through the string of well casing on a string of drill pipe (not shown) extending to the top of the well bore and through which drilling weight and rotary motion or torque is transmitted to the bit A.

In the form of invention specifically disclosed in the drawings, the rotary drill bit consists of a mandrel **10** having a suitable upper connection (not shown), such as an upper pin, threadedly connected, in a known manner, to the lower end of the string of drill pipe (not shown). The mandrel includes an upper kelly or drill stem member **11** slidably splined to the main body **12** of the bit. The exterior **13** of the lower portion of the kelly is non-circular in shape, being telescopically received in a companion non-circular socket **14** formed in the main bit body. As an example, the kelly exterior **13** and the socket **14** may be of hexagonal shape, which will allow the kelly **11** to move longitudinally within and with respect to the body **12** while still being capable of transmitting its rotary motion to the body.

The mandrel **10** has a limited range of longitudinal movement within the body, its downward movement being determined by engagement of the lower end **15** of the kelly with an inwardly directed body shoulder **16** and its upward movement being limited by engagement of a lower piston **17** fixed to the kelly with a lower cylinder head **18** secured to the body. As shown, the lower piston **17** is secured to the kelly against longitudinal movement with respect thereto by bearing upon a lower split snap retainer ring **19** received within a peripheral groove **20** in the kelly, and by an upper split snap retainer ring **21** received within a peripheral groove **22** in the kelly and engageable with the upper end of the piston. Leakage of fluid between the kelly or mandrel **11** and the lower piston **17** is prevented by a suitable side seal ring **23** mounted on the kelly and engaging the inner wall of the piston.

The upper portion of the body **12** constitutes a tandem cylinder **24** formed within an elongate counterbore **25** in the body extending downwardly from its upper end, the cylinder being spaced from the periphery of the mandrel **10** to provide an annular space **26** in which the lower piston **17** is relatively movable. Leakage of fluid between the lower piston **17** and the lower cylinder portion **27** of the tandem cylinder is prevented by a suitable side seal ring **28** mounted on the lower piston and engaging the wall of the cylinder.

The lower cylinder portion **27** is closed by the lower annular cylinder head **18** which is engaged by a lower piston **17** to limit the extent of upward movement of the mandrel **10** within the bit body **12**. The lower cylinder head is secured to the lower cylinder portion against longitudinal movement with respect thereto by engagement of an outwardly directed head flange **29** with a companion lower cylinder shoulder **30**, which may be deemed to constitute the upper end of the lower cylinder portion **27**. Upward movement of the lower head **18** along the cylinder is prevented by a split snap retainer ring **31** engaging and overlying the upper end of the lower head and received within an internal groove **32** in the cylinder **24**.

Another or upper annular piston **33** is secured to the

kelly portion 11 of the mandrel, and is spaced longitudinally from the lower piston 17. The lower end of the upper piston rests upon a split snap retainer ring 34 received within a peripheral groove 35 in the mandrel, its upper end engaging an upper split snap retainer ring 36 received within an upper peripheral mandrel groove 37. This upper piston is relatively slidable along the inner wall of an upper cylinder portion 38 of the tandem cylinder arrangement, leakage of fluid between the upper piston 33 and upper cylinder portion 38 being prevented by a suitable piston ring 39 mounted on the piston and slidably and sealingly engaging the wall of the upper cylinder portion. Leakage of fluid between the upper piston 33 and the mandrel kelly 11 is prevented by a suitable side seal ring 40 on the mandrel engaging the inner wall of the piston.

The upper cylinder portion 38 is closed by an upper annular cylinder head 41 above the upper piston 33, which is fixed to the upper cylinder portion in substantially the same manner as the lower cylinder head 18 is fixed to its companion cylinder portion. As shown in the drawings, the upper cylinder head 41 has an outwardly directed flange 42 bearing against an upwardly facing shoulder 43 on the upper cylinder portion, upward movement of the upper head with respect to the cylinder being prevented by its engagement with a split snap retainer ring 44 received within an internal groove 45 in the upper cylinder portion. An annular guide 46 is releasably secured to the upper cylindrical portion of the body in any suitable manner, this guide disposed above the upper retainer ring 44 and having a tapered surface 47 for guiding the bit past obstructions, and the like, during its upward movement in the well bore. Leakage of fluid between the heads 41, 18 and mandrel 10 is prevented by a suitable inner seal ring 48 carried by each head and slidably and sealingly engaging the periphery of the mandrel, leakage of fluid between the heads and their respective cylinder walls being prevented by a suitable side seal ring 49 on each head engaging its companion cylinder wall.

The operation of the tandem arrangement of pistons and cylinders will be described hereinbelow, as well as the mode of assembly of the parts. It is sufficient to state at this time that the inside diameter of the upper cylinder portion 38 is greater than the inside diameter of the lower cylinder portion 27, and that access openings or holes 50 are provided in the upper cylinder portion immediately above the split snap retainer ring 31 that secures the lower cylinder head 18 to its cylinder 27. When the parts of the expansible rotary drill bit are in their initial retracted positions, the lower piston 17 engages or is immediately below the lower cylinder head 18, the upper piston 33 being immediately below the upper cylinder head 41. Upper ports 51 lead from the central passage 52 through the kelley portion of the mandrel to a cylinder space 53 between the upper cylinder head and upper piston; whereas, lower ports 54 lead from this central passage 52 to a lower cylinder space 55 between the lower cylinder head 18 and lower piston 17. Bleeder holes 56 extend through the wall of the lower cylinder 27 immediately above the counterbore shoulder 57 to prevent any fluid in the annular cylinder space below the lower piston 17 from interfering with operation of the apparatus. Similar bleeder holes 58 may be provided in the upper cylinder 38 to prevent trapping of any fluid below the upper piston 33 that might interfere with proper operation of the apparatus. However, these upper bleeder holes 58 may be omitted in view of the ability of the fluid to bleed or to flow through the comparatively large access openings 50 through the cylinder wall.

The body has a plurality of expansible parts mounted on it. Such parts include cutter supporting members 60 pivotally mounted in one or more body slots 61 on hinge pins 62 suitably secured to the body 12. Each cutter supporting member depends from its hinge pin and carries a drag or milling cutter structure 63 on its lower end.

The cutter supporting members 60 and the cutter structures 63 themselves tend to occupy a retracted position substantially entirely within the confines of the main body 12 of the bit. These cutter supporting members and cutter structures are expandible outwardly to sever the casing C and mill it away by operating upon the upper end D of the casing C therebelow, after the severing action has been completed, or to enlarge the diameter of an existing well bore B, or both. To accomplish the expansion of the cutters, each cutter supporting member 60 has an inclined expander surface 64 on its inner portion below its hinge pin 62 which tapers in a downward and inward direction. Such expander surface terminates in an inner lock surface 65 formed on a lock portion 66 of the cutter supporting member. The outward expansion is actually accomplished by relatively shifting the mandrel 10 and the body 12 longitudinally of each other, which will produce relative longitudinal movement between the cutter supporting members 60 and the tubular member 67 of the mandrel 10 which depends from the kelly portion 11. This tubular member is elongate, being slidable within a bridge 68 secured in the body and extending across its slot or slots 61. The lower portion 69 of the tubular member is slidable within the body 12 below its slots 61, fluid from the passage 70 through the tubular member being adapted to discharge through a choke 71, suitably secured in the lower portion 69 of the tubular member 67, into a fluid chamber 72 in a pilot portion 73 of the body, which is suitably secured to the main portion of the body, as by use of welding material 74. Leakage of fluid between the lower portion 69 of the mandrel 10 and body 12 is prevented by a suitable side seal ring 75 mounted in the body and adapted to slidably seal against the periphery of the tubular member.

Upwardly and outwardly directed fluid passages 76 extend from the fluid chamber 72, these passages opening into the lower end of the body slots 61. At the upper end of the passages, nozzles 77 are suitably secured for directing the drilling fluid upwardly toward the cutters 63, for the purpose of cooling them and cleaning them of the cuttings, the cuttings produced by the cutters being carried by the fluid stream upwardly around the drill bit A and the string of drill pipe to the top of the well bore.

In the apparatus specifically illustrated, lateral passages 78 are also provided through the lower guide portion 73 of the body, communicating with the fluid chamber 72, each of these passages containing a jet nozzle 79 directed predominantly against the wall of the well bore, or well casing. To secure downward discharge of fluid from the body guide 73, lower passages 80 are also provided therein communicating with the fluid chamber 72. A nozzle 81 may be suitably mounted in each of these passages 80 for directing fluid predominantly in a downward or vertical direction into the well bore, to be capable of washing away accumulations of cuttings, and other materials, from the well bore.

Mounted on the tubular member 67 and located initially substantially above the body bridge 68, and below the hinge pins 62 and in cutter supporting member recesses 82, is a mandrel lock and expander 83, which has its outer surfaces 84 adapted to engage the expander surfaces 64 and the lock surfaces 65. This lock and expander 83 may be formed integrally with the tubular member 67. The upper end of the latter is piloted within a socket 85 formed in the lower portion of the kelly 11, an enlarged boss 86 on the tubular member engaging a downwardly facing kelly shoulder 87. The tubular member is held against this shoulder by a suitable split retainer or lock ring 88 snapped into an internal groove 89 encompassing the kelly socket and engaging the lower end of the tubular member boss 86. Fluid leakage between the boss 86 and the kelly 11 is prevented by one or more side seal rings 90 on the kelly engaging the periphery of the boss.

Assuming the body 12 of the tool to be elevated relatively along the tubular mandrel 10, the inclined expander surfaces 64 of the cutter supporting members 60 shift upwardly along the lock and expander portion 83 of the tubular member 67. During such upward shifting, the cutter supporting members 60 and the cutter structures 63 carried thereby pivot about the hinge pins 62 and are urged in an outward direction. Upward movement of the body 12 with respect to the mandrel 10 can continue until the cutter structures 63 have been shifted outwardly to their fullest extent, as determined by engagement of stop shoulder 91 on the cutter supporting members with companion shoulders 92 formed in the body 12 on opposite sides of the body slot or slots 61. When such engagement occurs, the lower end 15 of the kelly portion of the tubular mandrel engages the body shoulder 16 and the lock and expander 83 on the tubular member is disposed behind and in full engagement with the lock portions 66 of the cutter supporting members.

The relative longitudinal movement between the tubular mandrel 10 and the body 12 of the tool, to effect outward expansion of the cutters 63, is accomplished by pumping fluid under pressure downwardly through the tubular string of drill pipe (not shown) and into the mandrel passages 52, 70. Such fluid under pressure may be gaseous or liquid, consisting, for example, of compressed air or of drilling mud. The choke orifice 71 in the lower portion of the tubular member causes a back pressure to be built up in the kelly passage 52, the fluid under pressure passing through the upper and lower ports 51, 54 into the upper and lower cylinders 38, 27, acting simultaneously upon the upper and lower cylinder heads 41, 18 to urge the body 12 of the tool in an upward direction with respect to the tubular mandrel 10, to secure outward expansion of the cutter supporting members 60 and the cutter structures 63 to their fullest extent, as above described.

As shown, each cutter supporting structure 63 forms the lower portion of the cutter supporting member 60 and is expressly designed, in the specific device illustrated in the drawings, to sever the casing C and mill it away along a desired length, as well as to enlarge the diameter of the well bore B surrounding the casing. Each cutter structure includes cutter teeth 93, the leading faces of each tooth preferably being provided with a suitable hard-facing material extending from the lower end 94 of the tooth upwardly to a substantial extent along its leading face. Similarly, the outer surface or face 95 of each of the teeth may be provided with hard facing material. Such outer tooth surfaces 95 are effective in making an initial severing cut through the well casing C, or in initially enlarging the diameter of the well bore, until the cutters 63 have been expanded outwardly to their fullest extent, after which it is the lower ends 94 of the cutter teeth that are operable upon the upwardly facing end D of the severed well casing, or upon the formation shoulder E which defines the lower end of the enlarged well bore F, to mill away the casing, or to enlarge the diameter of the well bore, or both, in a downward direction.

When the cutters 63 are in their retracted position, such as disclosed in FIG. 1, the mandrel 10 is in an upper position with respect to the body 12 of the tool and the body bridge 68. At this time, the upper and lower cylinder heads 41, 18 are immediately above and adjacent to the upper and lower pistons 33, 17, respectively. Fluid is now pumped down through the drill string and the mandrel passages 52, 70, this fluid passing out through the choke orifice 71 and causing a comparatively large back pressure to be built up in the fluid within the kelly 11, which pressure is transmitted through the fluid in the upper and lower ports 51, 54 and the upper and lower cylinder spaces 53, 55 for simultaneous upward action on the upper and lower cylinder heads 41, 18 to elevate the body 12 and cutters 60, 63 with respect to the mandrel 10, the cutter structures moving upwardly along the expander member 83 and being shifted outwardly. During their outward shifting, the outer portions 95 of the cutter teeth engage the casing wall and effect a cutting thereon as the drill string and drill bit A are rotated, the rotary motion being transmitted from the mandrel 10 to the body 12 and from the body to the cutter supporting members 60 and cutters 63. As the casing is milled away, the cutters 63 are expanded outwardly to an additional extent under the upward force exerted by the fluid on both upper and lower cylinder heads 41, 18 to further elevate the body 12 with respect to the mandrel 10. The body moves upwardly until full cutter expansion has occurred, as determined by engagement of the lower end 15 of the kelly with the body shoulder 16, and by the coengagement between the body shoulders 92 and shoulders 91 on the cutter supporting members.

Drilling weight can now be imposed through the string of drill pipe on the madrel 10 of the tool, such weight passing downwardly through the body shoulder 16 to the body 12 and through the shoulders 92, 91 to the cutter supporting members 60 and the cutters 63 themselves, the lower ends 94 of the cutters being forced against the upwardly facing severed end D of the casing C and also against the formation shoulder E. Disintegration of the casing and of the formation can now occur as a result of rotation of the drill pipe and drill bit A, and the circulation of fluid down through the drill pipe and the bit, the fluid discharging through the choke 71 into the fluid chamber 72 and through the upper radial jet nozzles 79 and the lower nozzles 81 into the well bore, as well as upwardly from the chamber through the fluid passages 76 and the upper nozzles 77 toward the cutters 63, the fluid carrying the cuttings upwardly from the drilling region, around the drill bit A and the drill pipe, to the top of the hole.

During elevation of the body 12 along the mandrel 10 and forcing of the cutters 63 against the wall of the well casing C, as well as against the wall of the well bore, to effect the initial severing cut in the casing and enlargement of the well bore, the total fluid force available is comparatively great, since the unit fluid pressure is acting on the combined areas of the lower cylinder head 18 and the upper cylinder head 41 to urge the body 12 upwardly along the mandrel, the upward force being transmitted from the heads through their respective retainer rings 44, 31 to the cylindrical portions 38, 27 of the body of the tool. The total force available with the dual cylinder and piston arrangement disclosed is more than twice that which would be available if only the lower cylinder and piston were used, for example. More than double the total force is available because of the fact that the internal diameter of the upper cylinder portion 38 is greater than the internal diameter of the lower cylinder portion 27. Not only does the increased internal diameter correspondingly increase the total fluid force available for elevating the body 12 of the tool and cutters 63 with respect to the mandrel 10, but it also facilitates assembly of the several parts of the drill bit to one another, and their disassembly, as described hereinbelow.

After the desired length of casing C has been milled away, or the desired length of hole has been enlarged in diameter, a fluid jetting action, and even a cementing operation, can be performed in the well bore. Preferably, one of the lower nozzles 81 is closed against downward passage of fluid so that the fluid pumped down through the drill string and the mandrel passage into the fluid chamber 72 will flow primarily out through the upper jet nozzles 79, which are directed predominantly against the wall of the well bore F. A suitable ball 98 of a slightly greater diameter than the diameter of the passage through a lower nozzle 81, but of a lesser diameter than the minimum diameter through the choke 71, is dropped into the drill string and pumped downwardly therethrough and through the mandrel passage 52, 70, this ball coming to rest on one of the lower nozzles 81 to

close the passage therethrough. If the other lower nozzle is to be closed, a second ball can be pumped down through the tubing string to seat across the entrance to such other nozzle to close the passage therethrough. Thereafter, fluid pumped down through the tubular string and the mandrel will discharge into the chamber 72 and primarily out through the jet nozzles 79 and also through the fluid passages 76 into the well bore. The drill pipe and drill bit A can be rotated and moved upwardly along the exposed well bore F so that the fluid jets predominantly against the wall of the well bore to condition it. Thereafter, cemetitious material can be pumped down through the drill string and through the mandrel passages, discharging into the fluid chamber 72 and then outwardly through the jet nozzles 79 against the wall of the well bore F. During such discharging operation, the drill string and drill bit A are rotated to cover the full circumference of the well bore, the bit being slowly elevated to insure full deposition of the cementitious material, or other fluid or fluent material, in the well bore.

After the desired operation in the well bore has been performed, the apparatus A is removed therefrom. The pumping of fluid through the string of drill pipe and the apparatus is discontinued, which relieves the pressure in the upper and lower cylinders 38, 27. The drill pipe is then elevated, such elevating movement raising the tubular mandrel 10 with respect to the body 12 and the cutter supporting members 60, which raises the lock and expander portion 83 above the expander surfaces 64, whereupon the cutter supporting structures 60, 63 drop back to their retracted position, such as disclosed in FIG. 1. In the event the cutters 63 do not move readily to such position, an upwardly facing shoulder 99 on the tubular mandrel 67 engages inward projections 100 at the upper portions of the cutter supporting members 60, effecting an upward swinging of such projections about the hinge pins 62 and an inward shifting of the cutter supporting members 60 and the cutters 63 within the confines of the body. If such action still fails to shift the cutter supporting members inwardly to their fullest extent, they will engage the casing C above and adjacent to the location of the initial severing cut, upon elevation of the apparatus in the well bore, which engagement effectively forces the cutter supporting members 60 inwardly, enabling the apparatus A to be withdrawn through the well casing to the top of the well bore.

In assembling the mandrel 10 within the body 12 of the tool and the pistons and cylinders in appropriate relation to one another, the lower piston 17 is first slipped downwardly over the upper end of the kelly 11 and against the lower retainer ring 20, the inner side seal 23 having previously been mounted in place on the mandrel. The upper retainer ring 21 is then slipped downwardly over the kelly and into the upper groove 22 above the piston 17. The lower cylinder head 18 is then slipped downwardly over the kelly 11 and moves to a position above the lower piston 17. The lower piston and the lower cylinder head will, of course, have their seal rings appropriately mounted in place. The retainer ring 31 may then be disposed on top of the lower head. The lower snap retainer ring 34 for the upper piston 33 is then slipped downwardly over the kelly and mounted in its groove 35, followed by the upper piston 33, which is slipped downwardly over the kelly and into engagement with the retainer ring 34, the mandrel seal 40 having previously been installed. The upper snap retainer ring 36 is then slipped downwardly over the mandrel and mounted in its groove 37 to secure the upper piston to the kelly. The upper piston will also have its outer seal ring 39 mounted thereon.

The assemblage of the kelly 11 with its upper and lower pistons 33, 17 mounted thereon, and the intervening lower cylinder head 18 also mounted thereon, is then inserted downwardly into the tandem cylindrical portion 24 of the body. The lower piston 17 moves downwardly through the upper cylinder portion 38 very readily, inasmuch as the internal diameter of the latter is substantially greater than the external diameter of the lower piston. The lower cylinder head 18 enters the upper cylinder portion 38 and is pushed downwardly, together with its split snap retainer ring 31 along the wall of the upper cylinder portion by the upper piston 33. Such downward movement can continue to the extent at which the lower end 15 of the kelly engages the body shoulder 16, at which time the lower cylinder head is accessible from the exterior of the cylinder through the access openings 50. The lower cylinder head is grasped by suitable tools (not shown) and shifted downwardly until its flange 29 engages the lower body shoulder 30. The snap ring 31 can also be grasped by suitable tools and shifted downwardly along the cylinder wall until it snaps into its internal groove 32 to hold the lower cylinder head 18 in place.

The upper cylinder head 41 can then be readily inserted over the kelly 11, being moved downwardly therealong until its flange 42 engages the upper shoulder 43. The split snap retainer ring 44 is then slipped over the upper end of the kelly and moved down into the upper end of the cylinder 38, snapping into its groove 45 to secure the upper cylinder head to the upper cylinder portion. The upper guide 46 is then slipped over the kelly into its appropriate position within the upper end of the body of the tool.

Prior to insertion of the kelly 11 downwardly into the body 12 and into the assembled position referred to, the tubular member 67 is inserted down through the upper end of the body and into its lowermost position, as determined by engagement of its lock member 83 with the bridge 68. When the kelly 11 has been moved downwardly into the body, its lower socket portion 85 will receive the enlarged boss 86 of the tubular member; whereupon, the snap retainer ring 88, which has been previously placed around the tubular member, can be shifted upwardly into the kelly groove 89 under the enlarged boss 86 to secure the tubular member 67 to the kelly portion 11 of the mandrel 10.

Assembly of the bit can now be completed in a known manner by mounting the cutter supporting members 60 and cutters 63 in the slots 61 and inserting the hinge pins 62 in place.

Disassembly of the apparatus can also be accomplished easily. A procedure reverse to that mentioned above is followed. The guide 46 is released from the body 12 and removed from the upper end of the kelly. Through use of suitable tools, the upper snap retainer ring 44 is contracted and removed from its groove 45 and upwardly from the body, which allows the upper cylinder head 41 to be moved upwardly out of the body. Through use of a suitable tool inserted through one of the access openings 50, the retainer ring 31 for the lower cylinder head can be contracted, as, for example, by using a plier type of tool (not shown) having depending pins that will fit within holes 101 in the ring 31 on opposite sides of its split, the tool being manipulated to contract the ring and effect its removal from its groove 32, the ring then being moved upwardly from its groove, the tool being released therefrom and withdrawn from the access opening. The tubular member 67 is disconnected from the kelly 11 by contracting the snap ring 88 from its groove 89, whereupon the kelly 11 is moved upwardly, the lower piston 17 engaging the lower cylinder head 18 and shifting it, together with its retainer ring 31, upwardly along the upper cylinder wall and completely out of the cylindrical portion of the tool body.

The provision of the upper cylinder 38 with a larger internal diameter than the lower cylinder 27 provides the shoulder 30 between the upper and lower cylinder portions against which the lower cylinder head flange 29 can bear. It also facilitates assembly and disassembly of the lower piston 17 into its appropriate position

within the lower cylinder 27, as well as facilitating assembly of the lower cylinder head 18 in the body 12 of the tool, and its removal therefrom. Not only does the enlarged upper cylinder 38 facilitate such assembly and disassembly of the parts, but it also substantially increases the area of the upper cylinder relative to the area of the lower cylinder, correspondingly increasing the total force available for effecting outward cutter expansion, as compared to the force that would have been available had the upper cylinder 38 possessed the same internal diameter as the lower cylinder 27.

I claim:

1. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel longitudinally movable relative to and in said body; coengageable expander means on said mandrel and cutter means; upper and lower cylinders on said body; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively; said upper cylinder including a cylinder wall; said lower cylinder including a cylinder wall integral with said upper cylinder wall and an annular cylinder head separate from said lower cylinder wall and surrounding said mandrel between said pistons; means detachably securing one of said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means detachably securing said cylinder head to said lower cylinder wall; and means for directing fluid under pressure into said upper and lower cylinder above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to relatively shift said mandrel downwardly in said body and expand said cutter means outwardly.

2. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel longitudinally movable relative to and in said body; coengageable expander means on said mandrel and cutter means; upper and lower cylinders on said body; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively; said upper cylinder including a cylinder wall; said lower cylinder including a cylinder wall integral with said upper cylinder wall and an annular cylinder head separate from said lower cylinder wall and surrounding said mandrel between said pistons; means detachably securing one of said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said lower cylinder wall; one of said cylinder walls having an access opening therethrough for enabling attachment or detachment of said securing means; and means for directing fluid under pressure into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to relatively shift said mandrel downwardly in said body and expand said cutter means outwardly.

3. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel longitudinally movable relative to and in said body; coengageable expander means on said mandrel and cutter means; upper and lower cylinders on said body, said upper cylinder having a greater inside diameter than said lower cylinder; upper and lower pistons on said mandrel in said upper and lower cylinders, respectively, the outside diameter of said upper and lower pistons conforming to the inside diameter of said upper and lower cylinders, respectively; said lower cylinder including a cylinder wall and an annular cylinder head separate from said wall and surrounding said mandrel between said pistons; means detachably securing said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said cylinder wall; said cylinder wall having an access opening therethrough for enabling attachment and detachment of said securing means; and means for directing fluid under pressure into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to relatively shift said mandrel downwardly in said body and expand said cutter means outwardly.

4. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutting means mounted on said body for expansion laterally of said body; a mandrel connectible to the drill string and slidably splined to said body; coengageable expander means on said mandrel and cutter means; said mandrel having a fluid passage to receive fluid from the drill string; upper and lower cylinders on said body; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively; said upper cylinder including a cylinder wall; said lower cylinder including a cylinder wall integral with said upper cylinder wall and an annular cylinder head separate from said lower cylinder wall and surrounding said mandrel between said pistons; means detachably securing one of said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said lower cylinder wall; said cylinder wall having an access opening therethrough for enabling said securing means to be attached and detached; and means for directing fluid under pressure into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to elevate said body along said mandrel and expand said cutter means outwardly.

5. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to the drill string and slidably splined to said body; coengageable expander means on said mandrel and cutter means; said mandrel having a fluid passage to receive fluid from the drill string upper and lower cylinders on said body; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively; said upper cylinder including a cylinder wall; said lower cylinder including a cylinder wall integral with said upper cylinder wall and and annular cylinder head separate from said lower cylinder wall and surrounding said mandrel between said pistons; means detachably securing said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said cylinder of said lower cylinder wall; said cylinder wall of said lower cylinder having an access opening therethrough for enabling said cylinder head securing means to be attached or detached; and means for directing fluid under pressure from said passage into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to elevate said body along said mandrel and expand said cutter means outwardly.

6. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to the drill string and slidably splined to said body; coengageable expander means on said mandrel and cutter means; said mandrel having a fluid passage to receive fluid from the drill string; upper and lower cylinders on said body, said upper cylinder having a greater inside diameter than said lower cylinder; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively, the outside diameters of said upper and lower pistons conforming to the inside diameters of said upper and lower cylinders respectively; said lower cylinder including a

cylinder wall and an annular cylinder head separate from said wall and surrounding said mandrel between said pistons; means detachably securing said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said cylinder wall; said cylinder wall having an access opening therethrough for enabling said cylinder head securing means to be attached or detached; and means for directing fluid under pressure from said passage into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to elevate said body along said mandrel and expand said cutter means outwardly.

7. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to the drill string and slidably splined to said body; coengageable expander means on said mandel and cutter means; said mandrel having a fluid passage to receive fluid from the drill string; upper and lower cylinders on said body; said lower cylinder including a lower cylinder wall and a lower annular cylinder head separate from said lower cylinder wall, said upper cylinder including an upper cylinder wall integral with said lower cylinder wall and an upper annular cylinder head separate from said upper cylinder wall; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively, said lower piston being disposed below said lower cylinder head, said upper piston being disposed between said cylinder heads; means detachably securing said upper cylinder head to said upper cylinder wall; means detachably securing said lower cylinder head to said lower cylinder wall; means detachably securing said upper piston to said mandrel; one of said cylinder walls having an access opening therethrough above and adjacent to said lower cylinder head for enabling said lower cylinder head securing means to be attached or detached; and means directing fluid under pressure from said passage into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to elevate said body along said mandrel and expand said cutter means outwardly.

8. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel longitudinally movable relative to and in said body; coengageable expander means on said mandrel and cutter means; upper and lower cylinders on said body, said upper cylinder having a greater inside diameter than said lower cylinder; upper and lower pistons on said mandrel in said upper and lower cylinders, respectively, the outside diameter of said upper and lower pistons conforming to the inside diameter of said upper and lower cylinders, respectively; said lower cylinder including a cylinder wall and an annular cylinder head separate from said wall and surrounding said mandrel between said pistons; means detachably securing one of said pistons to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said cylinder wall; said cylinder wall having an access opening therethrough for enabling attachment and detachment of said cylinder head securing means; and means for directing fluid under pressure into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to relatively shift said mandrel downwardly in said body and expand said cutter means outwardly.

9. In a rotary drill bit to be lowered in a well bore on a rotary drill string: a body; cutter means mounted on said body for expansion laterally of said body; a mandrel connectible to the drill string and slidably splined to said body coengageable expander means on said mandrel and cutter means; said mandrel having a fluid passage to receive fluid from the drill string; upper and lower cylinders on said body, said upper cylinder having a greater inside diameter than said lower cylinder; upper and lower pistons on said mandrel movable in said upper and lower cylinders, respectively, the outside diameter of said upper and lower pistons conforming to the inside diameters of said upper and lower cylinders, respectively; said lower cylinder including a cylinder wall and an annular cylinder head separate from said wall and surrounding said mandrel between said pistons; means detachably securing said upper piston to said mandrel to permit disposition of said cylinder head on said mandrel between said pistons; means securing said cylinder head to said cylinder wall; said cylinder wall having an access opening therethrough for enabling said cylinder head securing means to be attached or detached; and means for directing fluid under pressure from said passage into said upper and lower cylinders above said upper and lower pistons, respectively, for simultaneous action on said pistons and cylinders to elevate said body along said mandrel and expand said cutter means outwardly.

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